

Kaufman - Trading Systems & Methods - Chap06

Chap06

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6 Momentum and Oscillators

The study of momentum and oscillators is an analysis of price changes rather than price levels. Among technicians, momentum establishes the speed of price movement and the rate of ascent or descent. Analysts use momentum interchangeably with slope, a straightline angle of inclination of price movement as measured from a horizontal line representing time. Momentum is also thought of as force or impact; it is often considered, as in Newton's Law, that once started prices tend to remain in motion in a somewhat straight line.

Rateofchange indicators, such as momentum and oscillators, are used as leading indicators of price change. They can identify when the current trend is no longer maintaining its same level of strength. This gives the trader an opportunity to begin liquidating the opentrend trades before prices actually reverse. As the time period for the momentum calculation shortens, this technique of leading a trend changes to become more aggressive and is interpreted as a countertrend method. Use of a rateofchange indicator anticipates change even sooner.

Before beginning a discussion of various momentum calculations, a brief comment on terminology will be helpful to understand how various techniques are grouped together. We begin with a single price, which has no movement. When we talk about bonds at 110 or gold at \$400 per ounce, we are relating a price level and not implying that prices are going up or down. Next, we describe the speed at which prices are rising or falling. It is not enough to say that the S&P rose 3 points~ rather, you must specify. the time interval over which this happenedTheS&P rose 3 points in one hour.'When you say that you drove your car at 60, you really imply that you were going 60 miles per hour, or 60 kilometers per hour. This description of speed, or distance covered over time. is the same information that is given by a single momentum value.

The last measure is one of change in speed, which is either acceleration or deceleration. The price of the Deutschemark may have risen by .0150 dollars per mark in the past week, indicating an average speed of .0150/5, or a rise of .0030 dollars mark per day however, it started rising slowly and increasing its speed over the week. Perhaps the mark rose .0010 on Monday, .0020 on Tuesday, .0030 on Wednesday, .0040 on Thursday, and .0050 on Friday, increasing in speed (or accelerating) by.0010 each day, The term rate of change (ROC) will also be used to describe acceleration; when the rate of change is zero. we are talking about speed and momentum.

You will see in this chapter that speed is a more sensitive measurement than price level, and acceleration is more sensitive than speed. The various techniques described here are presented in order of speed and then rate of change. Following that is divergence, the most popular use of momentum indicators.

MOMENTUM

Momentum is the difference between two prices taken over a fixed interval. It is another word for speed, the distance covered over time. For

example, today's 5day, momentum value M would be the difference between today's price P , and the price 5 days ago:

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$$(5\text{-day}) M = P_t - P_{t-5}$$

Using notation familiar to many programmers

momentum = price - price[5]

or

momentum = price - price[N]

where the notation [N] refers to the (closing) price N days ago

The momentum value M_t increases as the change in price over the 5-day period. Figure 6-1 shows that momentum is also related to the slope of the price line. An upward increase will cause both angle α to become larger and the momentum value, marked "momentum," to increase. If the 5-day momentum is 20, the momentum line can be expressed as $100/5 = 20$. If prices had increased at the same time interval, the slope would be $150/5 = 30$ and the momentum value would be 30.

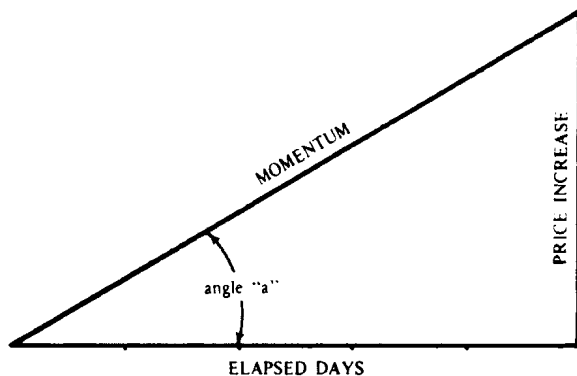
The 5-day momentum M_t can range in value from the maximum downward move that the price can make in 5 days to the maximum upward move. If prices are unchanged after 5 days, Figure 6-2 shows the possible range of momentum. Consider a commodity with a 20-point daily limit on price change. If the price *increased at a faster rate* for 8 days (up 2, up 4, up 6, up 8) were moving at their fastest 5-day rate. At point B the 5-day price change was the maximum 100-point change, or 60 points. From point B the price continued to increase, but at a slower rate, until the 5-day difference at point C was zero. From point C the price declined at an increasing rate until at point D the maximum 5-day decline was reached; at point E the 5-day difference was again zero. Note that the price started down but only increased at a slower rate; only at C did it start to decline.

Momentum as a Percentage

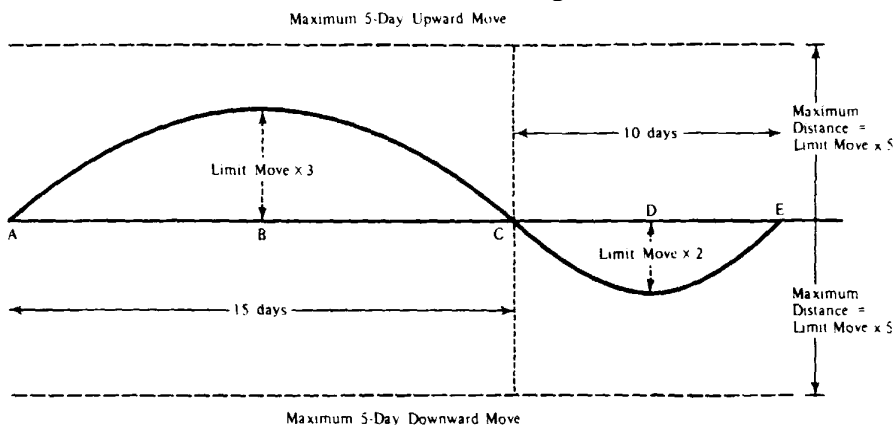
Momentum, as most other calculations, can be expressed as a percentage rather than a raw value of its components. This is usually done by dividing the current value by the previous price or index level, so that a 5day momentum may be

$$\%M = \frac{P_t - P_{t-5}}{P_{t-1}} \quad \text{or} \quad \frac{P_t - P_{t-5}}{P_{t-5}}$$

FIGURE 61 Geometric representation of momentum.



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FIGURE 62 Momentum range.



The difference in the two approaches is limited by the percentage change in the underlying price over the 4-day period between t_1 and t_5 . It is not likely that the change will even be noticeable on a chart of %M, and it is best to standardize the approach to taking percentages using t_1 .

Price and Trend Difference

It is common for the term momentum to refer to the difference between today's price and a corresponding moving average value. The properties of this new value remain the same. As the momentum becomes larger, prices are moving away from the moving average at a faster rate. When it gets smaller, the prices are converging with the moving average. Unlike the first definition of momentum, a value that is positive but converging toward the moving average may actually represent declining prices rather than prices that are advancing at a slower rate. The major similarity is that the peak of the price move is near the extreme points of the momentum chart.

Figure 63a (upper panel) shows 10-period and 40-period moving averages plotted on a 15-minute German bund chart. Figure 63b (center panel) shows the difference between the price and the 40-period moving

average; the momentum value is fairly uniform, varying by about .50 above and below zero. Because the moving average tends to catch up to prices over time, the maximum variation of the momentum measured this way is not as extreme as when momentum is calculated as the difference between two prices. This momentum calculation has also been called relative strength, because it is measured relative to a moving average.

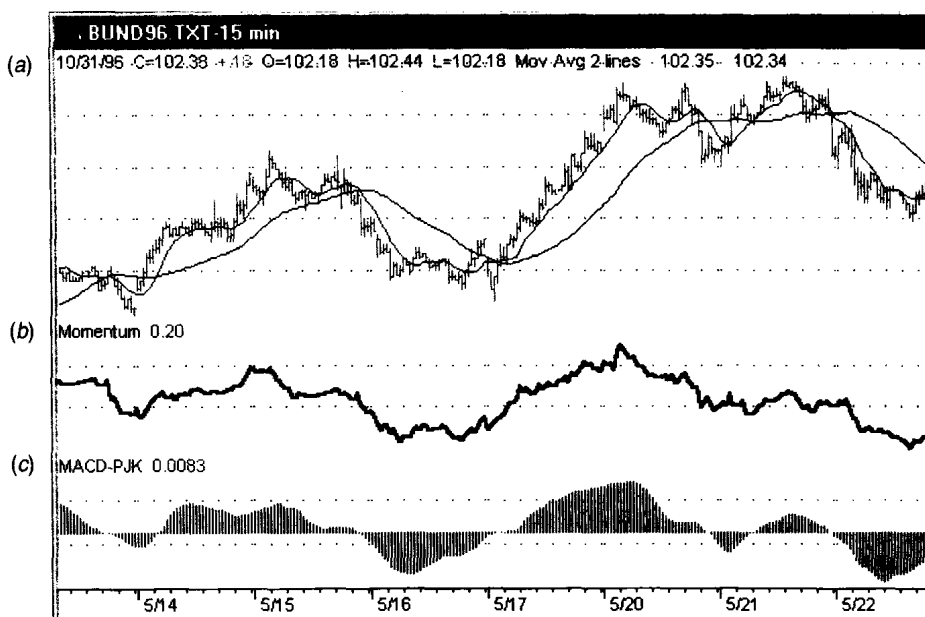
Moving Average Convergence/Divergence (MACD)

Momentum may also be seen as the difference between two moving averages, a technique developed by Gerald Appel and named the Moving Average Convergence/Divergence (MACD).¹ In its original form, the two trendlines were produced using exponential smoothing, and their difference resulted in the MACD value. This was further smoothed to give a signal line. The most common presentation of MACD uses the difference between a 12day and 26day exponential smoothing. The signal line, used to produce trading rec

¹From John D. Becker, "Value of oscillators in determining price action," *Futures* (May 1994).

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FIGURE63 Momentum as relative strength, the difference between prices and a moving average, or between two moving averages (MACD). (a, top panel) 10day and 40day moving averages plotted with 15minute German bund prices. (b, center panel) Momentum as the difference between prices and the 40day moving average. (c, bottom panel) MACD as the difference between the 10day and 40day moving average values.



Source: Chart created with TradeStation® by Omega Research, Inc.

ommendations, is a 9day smoothing of today's MACD subtracted from

today's MACD. in programming code, the function @SmoothedAverage refers to an exponential smoothing:

```
MACD = @SmoothedAverage(close,12)
signal_line = MACD - @SmoothedAv
```

The basic rules for trading the MACD would enter trend positions by referring only to the signal line calculation. Buy when the signal line moves above zero, and sell when the signal line falls below zero. Many traders, however, prefer to use the combination of MACD and signal line for signals, buying when the signal line crosses above the MACD line and selling when it crosses below. The signal line could be used to produce countertrend signals, as is common when using the stochastic (discussed in the section "Oscillators" in this chapter), by selling when the MACD crosses the signal line heading down while still above zero.

Because both moving averages are lagged, the peaks identified by the difference between the two will also be lagged. This is contrary to the usual purpose of the momentum indicator, which is to identify the precise time when an extreme has been reached. Looking at Figure 63c (bottom panel), the difference between the 10day and 40day moving averages is shown as a histogram, a form most commonly used for the MACD. it can be seen that the peak formed by the widest difference between the two moving averages is generally a few bars to the right of the peak seen on the price chart and the simple momentum line in Figure 63b.

An advantage of using MACD, as shown in Figure 63, is that the pattern is very smooth compared with both prices and the single momentum line, and the trend of the MACD pattern is often a leading indicator of price change. The peak prices that occur on both May

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15th and May 20th are followed by a sideways price pattern over the remaining part of the day; however, the MACD declines smoothly, indicating price weakness. It would be difficult to use the momentum calculation in Figure 63b, because it still contains much of the erratic price movements.

Timing an Entry

Momentum is a convenient way of identifying a good entry point caused by a price reversal during a trend. By choosing a much shorter time period for the momentum calculation, for example 6 days, to work in conjunction with a longer trend of 30 to 50 days, the momentum indicator will show frequent opportunities within the trend. The short time period for the momentum calculation assures you that there will be an entry opportunity within about 3 days of the entry signal; therefore, it becomes a practical timing tool.

Momentum as a Trend Indicator

The momentum value is a smoothing of price changes and can be very similar to a standard moving average. Most applications use momentum as a substitute for a price trend. BY looking at the net increase

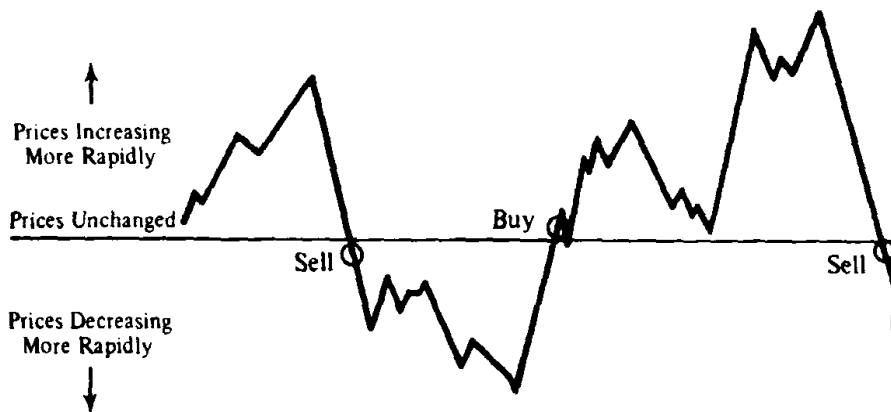
in prices over the number of days designated by an nday momentum indicator, intermediate fluctuations are ignored, and the pattern in price trend can be seen. The longer the span between the observed points, the smoother the results. This is equivalent to faster and slower moving averages.

To use momentum as a trend indicator, the momentum span is selected and plotted as in Figure 64. A buy signal occurs whenever the value of the momentum turns from negative to positive, and a sell signal is when the opposite occurs. If a band is used to establish a neutral position or a commitment zone, as discussed in Chapter 5, it should be drawn around the horizontal line representing the midpoint momentum value, usually zero.

Buy and sell signals that occur sooner and are likely to be stopped out more often, use a signal line created by smoothing the momentum values, in this case using a simple 3day moving average. Once the momentum value moves above a threshold level of, for example, 70, a sell occurs when the momentum crosses below the signal line. The position may be stopped out when the momentum crosses above the signal line, or when momentum moves above its entry level.

To find the best choice of a momentum span, a sampling of different values could be tested for optimum performance, or a chart could be examined for some natural price cycle. Identify the significant tops and bottoms of any bar chart, and average the number of days between these cycles, or find the number of days that would closely approximate

FIGURE 64 Price momentum signals with and without a signal line.



the occurrences of these peaks and valleys. These natural cycles will often be the best choice of a momentum calculation interval (Figure 65a).

Momentum and oscillators, however, are used just as often to identify abnormal price movements and for timing of entries and exits in conjunction with a longerterm trend.

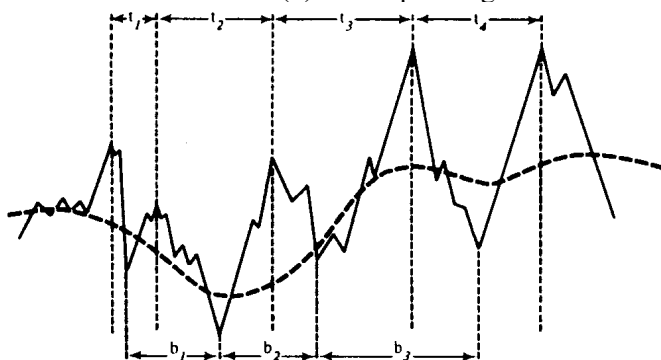
Identifying Extremes

An equally popular and more interesting interpretation of the

momentum chart is based on an analysis of tops and bottoms. All momentum values are bounded in both directions by the maximum move possible during the time interval represented by the span of the momentum. The conditions at the points of high positive and negative momentum are called overbought and oversold, respectively. A market is overbought when it can no longer sustain the strength of the current trend and a downward price reaction is imminent; an oversold market is ready for an upward move. Faster momentum calculations win reach these maximum values more often and stay there for extended periods of high upward or downward momentum. The use of a slow momentum period, however, will produce values that rarely test its limits. If the momentum system uses the horizontal zero line to enter and exit trades, it is of no consequence how often the bounds are touched; once a position is entered, the high momentum condition serves as a positive reinforcement for the trade. However, the maximum positive and negative momentum values can be measured and used to anticipate the end of a trend. For this purpose, momentum values that are too fast will obscure the trading signal the momentum index must be allowed to reach its full value.

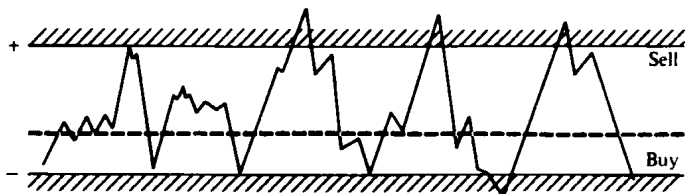
A system that takes advantage of the momentum extremes may be created by drawing two horizontal lines on the momentum graph (Figure 65b), above and below the zero line

FIGURE 65 Relationship of momentum to prices. (a) Tops and bottoms determine momentum value. (b) Corresponding momentum.



Tops and Bottoms Determine Momentum Value

(a)



Corresponding Momentum

(b)

in such a way that the tops and bottoms of the major moves are isolated. These lines may be selected visually so that once the line is penetrated, prices reverse shortly afterward. Another selection might simply be based on a percentage of the maximum possible momentum value. A third statistical approach would be to use a multiple of the standard deviation, or some other probability distribution function, so that the band is formed by the zero line plus or minus two standard deviations. That is, about 95% of all values within the area are bounded by the two horizontal lines.

When positioning these bands, there is always a tradeoff between finding more trading opportunities and entering the market too soon. This can be a complicated choice and is discussed in Chapter 22 ("System TradeOffs"). Once these lines have been drawn, the basic trading rules will be one of the following:

1. Aggressive. Enter a new long position when the momentum value penetrates the lower bound; enter a new short position when the value penetrates the upper bound.
2. Minor confirmation. Enter a new short position on the first day the momentum value turns down after penetrating the upper bound (the opposite for longs).
3. Major confirmation. Enter a new short position when the momentum value penetrates the upper bound coming down (the opposite for longs).
4. Timing. Enter a new short position after the momentum value has remained above the upper bound for t days (the opposite for longs).

To close out a profitable position there are the following alternatives:

1. Close out long positions or cover short positions when the momentum value satisfies the entry condition for a reverse position.
2. Cover a short position when the momentum penetrates the zero line minus one standard deviation, or some target point (e.g., halfway between the zero line and the lower bound).
- 3 Cover a short position if the momentum recrosses the zero line, moving up after penetrating that line moving down.

A protective stoploss order may be used to prevent giving up all profits (as in the last point) or to protect the trader from a sustained move that causes the momentum value to remain on the outside of the overbought/oversold lines.

1. Place a protective stop above or below the most extreme high or low momentum value.
2. Follow a profitable move with a nonretreating stop based on fixed points or a percentage.
3. Establish zones that act as levels of attainment (using horizontal lines of equal spacing), and do not permit reverse penetrations once entered.

These precautions are due to both normal price variability and volatility. As prices reach higher levels, increased volatility will cause momentum tops and bottoms to widen; at lower levels, they may not be active enough to penetrate the bounds. A penetration level established

when coffee prices were 504 per pound and the maximum daily range was 2c would not work with coffee at \$2.50 per pound and limits of 4c. A reasonable modification to the momentum plot would be the use of a band or stoploss, which is a percentage of price, or a percentage of the permissible limit move (a volatility function). The tops and bottoms would remain more inline although the risk would increase appreciably. This, however, is the intention of the oscillator.

When selecting trading rules for a countertrend technique, risk must be the primary concern. Using entry option 1, a short signal will occur upon penetration of the upper level, this may happen when the market is very strong. If an immediate reversal does not

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occur, large open losses may accrue. One solution might be to place a fixed stoploss at the time of each entry. To determine the proper stoploss amount, a computer test was performed using an immediate entry based on penetration of an extreme boundary with a close stoploss for risk protection. The first results were thought to have outstanding profits and consistency until it was discovered that the computer had done exactly the opposite of what was intended: It bought when the momentum crossed the upper bound and placed a close stoploss below the entry. It did prove, for a good sampling of commodities, that high momentum periods continued for enough time to capture small but consistent profits. It also showed that entry rule 1, anticipating an early reversal, would be a losing strategy. One should never forget that declining momentum does not mean that prices are failing.

OSCILLATORS

Because the representation of the momentum index is that of a line fluctuating above and below a zero value, this technique has often been termed an oscillator. Even though it does oscillate, the use of that word is confusing. In this presentation, the term oscillator will be restricted to a specific form of momentum, or rate of change indicator, which is normalized and expressed in terms of values that are limited to the ranges between +1 and 1, +1 and 0, or 100 and 0, as in percent.

To transform a standard momentum calculation into the normalized form (maximum value of +1, minimum value of 1), divide the momentum calculation by the maximum attainable value of the momentum index. A 5day index for silver with a 20limit move could be divided by \$1.00 to find the normalized value. If silver were to move its limit up for 5 days, the oscillator would have the value of +1 rather than the momentum value of 100. If the limits were to expand, the divisor would change as well, giving the technique a means of adjusting for varying volatility. Using the normalized momentum, or oscillator, the top and bottom zones become volatility adjusted at any level.

Erratic movements in the simple momentum and oscillator make it a very difficult tool to apply without additional work. Some of these problems can be eliminated by making the buying and selling zones more extreme or by smoothing the indicator values. In the following sections, a few of the applications of this technique are shown.

Relative Strength Index

One of the most popular indicators for denoting overbought and oversold conditions is the Relative Strength Index (RSI) developed by Wilder.² It provides added value to the momentum indicator by scaling all values between 0 and 100. It is more stable than momentum because it uses all the values in the period rather than just the first and last. It is a simple measurement that expresses the relative strength of the current price movement as increasing from 0 to 100. It is calculated as

$$RSI = 100 - \left(\frac{100}{1 + RS} \right) = 100 \times \left(\frac{RS}{1 + RS} \right)$$

where $RS = \frac{AU}{AD}$

AU = the total of those days closing higher during the past

AD = the total of those days closing lower during the past

Once the first calculation has been made, both the AU and AD are updated daily using an *average-off* method:

² J. Welles Wilder, Jr., *New Concepts in Technical Trading Systems* (Trend Research)

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$$AU_{\text{today}} = AU_{\text{prior}} - \frac{AU_{\text{prior}}}{14} + \text{today's up close or 0}$$

$$AD_{\text{today}} = AD_{\text{prior}} - \frac{AD_{\text{prior}}}{14} + \text{today's down close or 0}$$

This method essentially drops an average value and adds the new value, if any. The daily calculation of the RSI becomes simple.

Wilder has favored the use of the 14day measurement because it represents onehalf of a natural cycle. He has set the significant levels for the RSI at 30 and 70. The lower level is indicative of an imminent upturn and the upper level of a pending downturn. A plot of the RSI can be interpreted in the same manner as a bar chart, with the headandshoulders formation as the primary confirmation of a change in direction (Figure 66).

In fact, Wilder relies heavily on top and bottom formations for RSI signals. More often than head and shoulders, the failure swing or divergence denotes an unsuccessful test of a recent high or low RSI value. Modifying the RSI

An obvious objection to the RSI might be the selection of a 14day halfcycle. Maximum divergence is achieved by the use of a moving

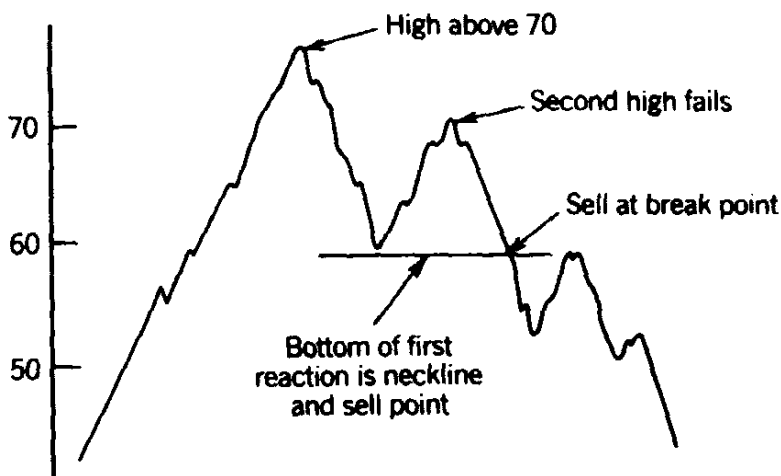
average that is exactly onehalf the length of the dominant cycle, but 14 days may not be that half cycle. In addition, commonuse chart interpretation might mean that the RSI value remains outside the 7030 zones for extended periods rather than signaling an immediate turn.

In practical terms, a 14day criterion means that a sustained move in one direction that exceeds 14 days will retain a very high RSI value and may result in losses if a short position was entered. if the trading of the RSI seems to have high risk, increase the overbought and oversold levels by moving them from 7030 to 8020. This will cause a signal to be given at a more extreme level.

The generalized program code for an nday RSI is given as

```
sumup = 0;
sumdn = 0;
for i = 1 to n begin
    if close - close[i] > 0 then
        sumup = sumup + close - close[i]
    else sumdn = sumdn + close[i] - close
end;
RSI = 100 - (100 / (1 + (sumup/sumdn)));
```

FIGURE 66 RSI top formation.



A study by Aan³ on the distribution of the top and bottom was consistently grouped near all RSI values lie between 72 and 32, which is to a standard deviation. This would suggest the too close together to act as selective overboughter apart.

The frequency at which the market will re changing the 14-day criteria. If the interval is often and trades will have higher risk. If the time fewer trades based on RSI extremes (discussed safer to err on the side of less risk. If there are a combination of a longer interval and higher

Further Smoothing with N-Day Ups and Downs

Instead of increasing the number of days in the indicator can be found by increasing the period over determined. The original RSI method uses 14 which the price change was positive. Instead 2-day change, or an n -day change. If we use 2 needed, so that each 2-day period does not over Using 14 sets of 2 will give a smoother indicator

Net Momentum Oscillator

Another variation on the RSI is the use of the and the sum of the down days, called a *net* unsmoothed $RSI = 100 \times (S_u / (S_u + S_d))$, then the $100 \times (S_u - S_d) / (S_u + S_d)$. This method replaces smoothing in the normal RSI and shows more ening the number of periods in the RSI calculation

Stochastics

The *stochastic*, created by George Lane, is an of the closing price within a past high-low range observation that closing prices tend to resist upward move gains strength; similarly, closing a decline. When the market is about to turn for case that the highs are higher, but the closing makes the stochastic oscillator different from representations of the *relative strength*, the d selected trend speed.

The three indicators that result from the and %D-slow. The first two calculations form tor and are calculated for today t as

$$\text{Initial \%}K_t = 100 \times \frac{C_t - L_t(5)}{R_t(5)}$$

³ Peter W. Aan, "How RSI Behaves," *Futures* (January 1985).

⁴ For a more sophisticated approach to RSI optimization, see *Journal of Technical Analysis of Stocks & Commodities* (February 1986).

⁵ Tushar S. Chande and Stanley Kroll, *The New Technical Trading*

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$$\%D = \text{"\%}K_t\text{-slow"} = \frac{\%K_t + \%K_{t-1} + \%K_{t-2}}{3} = \frac{\left(\sum_{i=t-2}^t \%K_i \right)}{3}$$

$$\%D_t\text{-slow} = \frac{\left(\sum_{i=t-2}^t \%D_i \right)}{3}$$

where C_t is today's closing price

$L_t(5)$ is the low price of the last 5 days

$R_t(5)$ is the range of the last 5 days (highest high minus lowest low)

Notice that $\%D$ is a 3day moving average of $\%K$, and $\%D_{\text{slow}}$ is a 3day moving average of $\%D$. The 5day high, low, and range selections tend to make the smoothed stochastics, $\%D$ and $\%D_{\text{slow}}$, frontloaded calculations. Figure 67 shows the price of July 1981 cotton plotted with the corresponding $\%D_{\text{slow}}$ and $\%D$ ($\%K_{\text{slow}}$) stochastic. Notice that the extremes do not correspond to what would be expected using a 5day simple momentum. Points A and B appear much weaker in the stochastic than on the line chart, while points C and D are more pronounced. The low at point E is confusing, perhaps due to the gap in data; otherwise, the stochastic would seem a unique and useful tool. The smoothed value $\%D_{\text{slow}}$ does not lag as much as the 3day average would imply, supporting the premise that there is significant weighting given to the more recent prices. The first calculation, $\%K$, is not used due to its instability.

Interpreting the Stochastic

The initial trading signal occurs when the $\%D_{\text{slow}}$ crosses the extreme bands. Suggested in the range of 75 to 85 on the upside, and 15 to 25 on the downside. The order, however, is not placed until the $\%K_{\text{slow}}$

line crosses the W %Dslow line (considered the signal line) . Even though the extreme zone helps assure an adverse reaction of minimum size. The crossing of the two lines acts in a way similar to a dual moving average system. By waiting for the crossover, the trader cannot be trapped into shorting an extremely bullish move or buying a bearish one.

The emphasis in interpretation of the stochastic is its divergence from the apparent direction of prices. Referring again to Figure 67, points A and B are declining while new high prices at A are tested at B. This divergence is an important confirmation of the sell indication.

Patterns noted by Lane' are more extensive than other writings. They include:

Left and Right Crossovers

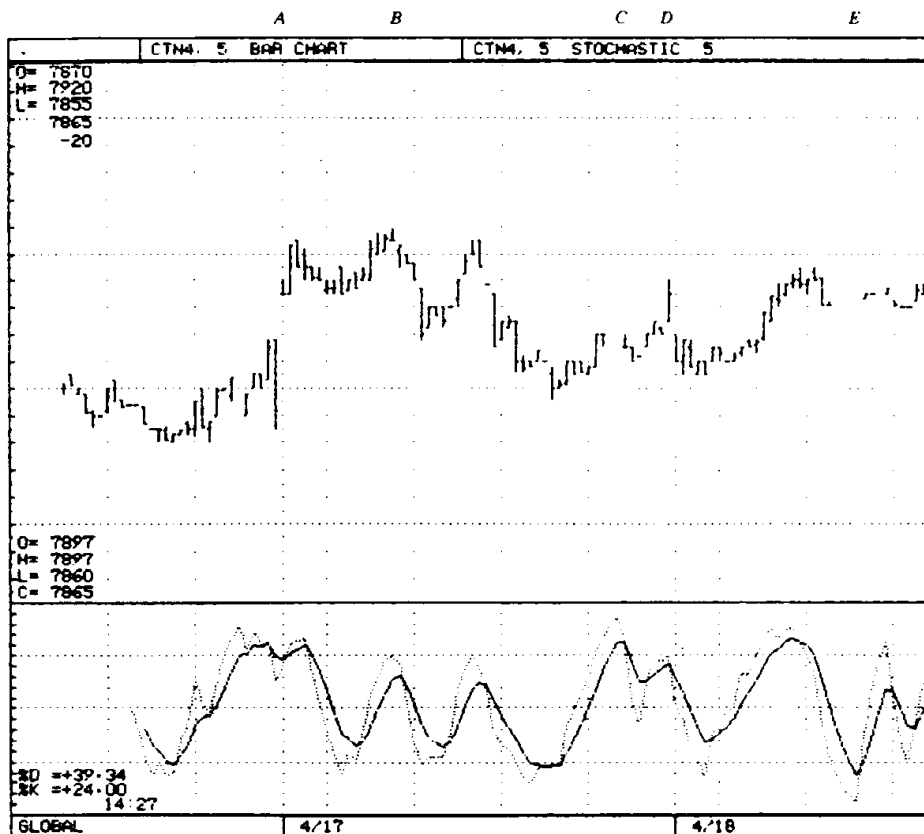
Typically, the faster %Kslow will change direction sooner than the %Dslow. crossing the %Dslow line while it is still moving in the prior trend direction, The opposite case. when the %Dslow turns first, indicates a slow, stable change of direction and is a more favorable pattern (Figure 68a).

Harry Schirding, Stochastic Oscillator, Technical Analysis of Stocks & Commodities (May/June 1984 For a pocket computer version of these calculations. see C.F johnson, Stochastic Oscillator Program for the HP41C(V), Technical Analysis of Stocks & Commodities (September/October 1981).

It is common practice to use the notation %K and %D to mean %Kslow. and %Dslow: respectively All writings on the stochastic use the smoothed values. rather than the initial %K calculation. regardless of the omission of –"slow" Any, use of %K in this text will also refer to %Kslow. unless specifically, stated.

George C.. Lane. Lane's Stochastics, Technical Analysis of Stocks & Commodities (May/June 1981)

FIGURE 67 The stochastic. A 5minute bar chart of July 1984 cotton futures (NewYork Cotton Exchange) as recorded by a Commodity QuoteGraphicsTQ20120 satellite system. Cotton's 5period stochastic is plotted below the bar chart.



Hinge

A reduction in the speed of either the %Kslow or %Dslow lines, shown as a flattening out, indicates a reversal on the next day (Figure 68b).

Warning

An extreme turn in the faster %Kslow (2 to 12%) indicates at most 2 days remaining in the old trend.

Extremes

Reaching the extreme %Kslow values of 0 and 100 requires 7 consecutive days of closes at the highs (lows). The test of this extreme, following a pullback, is an excellent entry point.

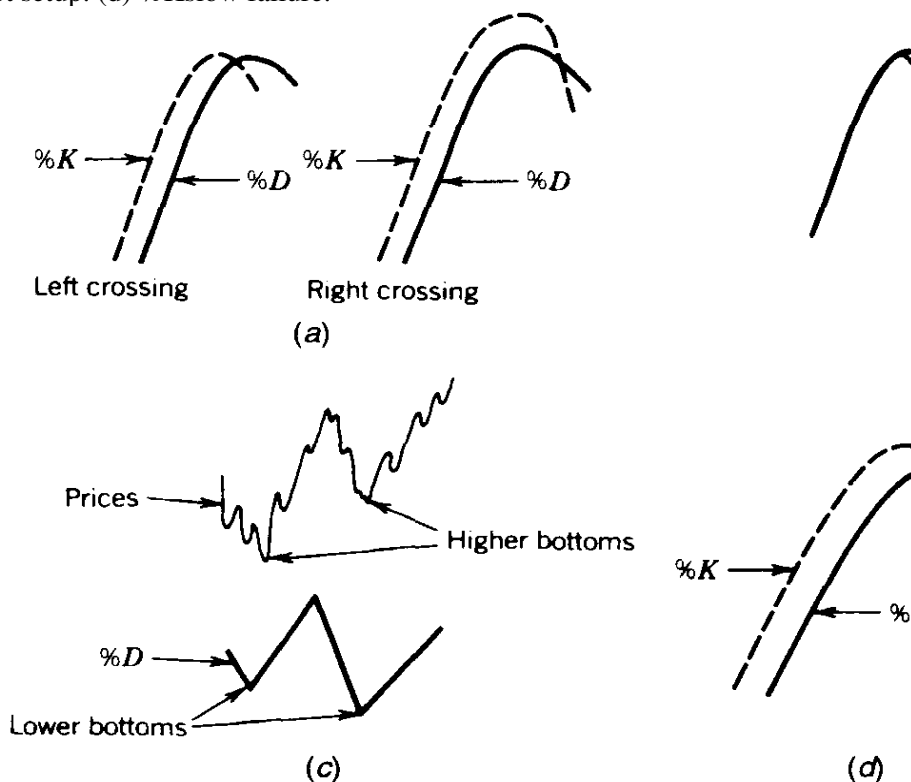
Setup

Although the line chart shows higher highs and lows, if the %Dslow line has lower lows, a bear market setup has occurred. Look for a selling opportunity on the next rally (Figure 68c).

Failure

An excellent confirmation of a change in direction occurs when %Kslow crosses %Dslow (after penetrating the extreme level) then pulls back to the %Dslow line, but fails to cross it again (Figure 68d).

FIGURE 68 Lane's patterns. (a) Left and right crossings. (b) Hinge. (c) Bear market setup. (d) %Kslow failure.



Relative Speed and Patterns of the Stochastic and RSI

Increasing the calculation period is a way of smoothing the values of indicator, whether it is viewing weekly instead of daily prices, using a 200day average instead of a 10day, or selecting a 20day stochastic over a 5day. The two most popular oscillators, the RSI and stochastic, can be very similar if the time periods are chosen correctly. In Figure 69, a Treasury bond chart for June 1996 delivery is used to show how the RSI and stochastic patterns change by varying the number of days in the calculation.

The 5day raw stochastic is shown in panel b of Figure 69. Its characteristic is that whenever prices close on a 5day high or low, the stochastic value is 100 or 0 and the indicator cannot provide any value. Smoothing the raw value offsets this problem at the cost of introducing a lag; this example will avoid that additional problem and use only the raw stochastic. Figure 69 (panel c) contains a 5day RSI that tends to show similarities to the 5day stochastic as bond prices become more actively traded toward the right part of the chart. Nevertheless, the RSI does not tend to approach peak values. Smoothing the stochastic by using 20 days, as shown in Figure 69 (panel d), gives a very similar picture as the 5period RSI in panel c of Figure 69. The pattern has all the same ups and downs,

although the stochastic continues to show more extreme values. The last two panels of Figure 69 (panels c and f) compare the standard 14period RSI with a much longer 40day stochastic with similar results as in Figure 69 (panels c and d). The patterns are very similar, but the stochastic moves to extremes more often.

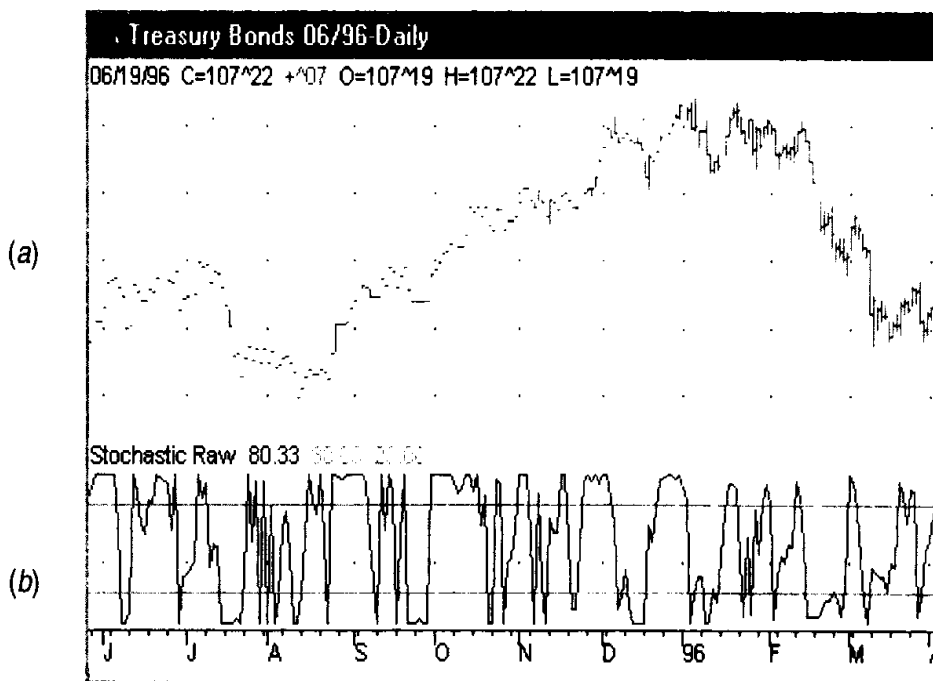
Creating a Stochastic from the RSI

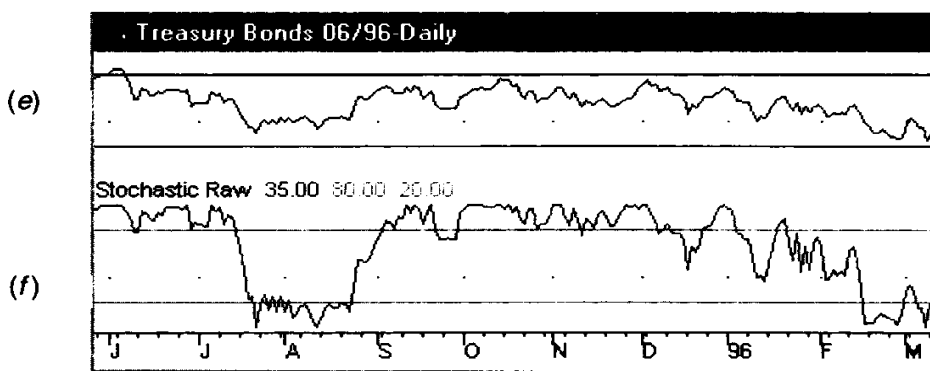
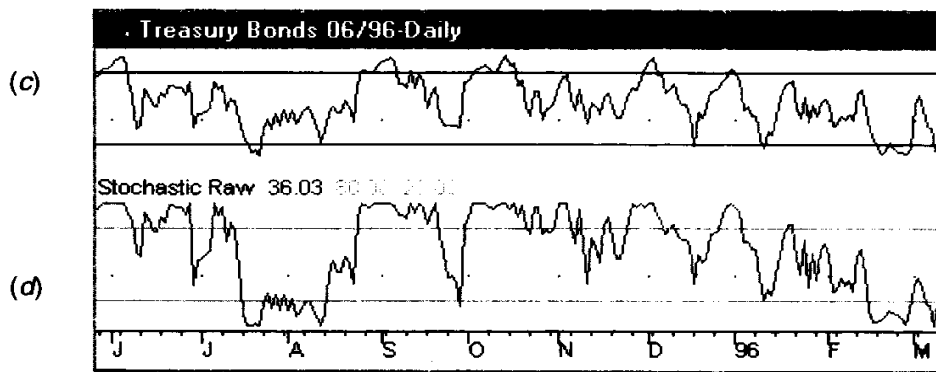
Any series or indicator value can be converted to a raw stochastic, %K without adding lag by replacing the closing price with the indicator value. This creates a measure of where that indicator lies in its highlow range over the period selected and may simplify the comparison needed to generate buy and sell signals. A stochastic created from an RSI would be,

¹Tushar Chande and Stanley Kroll, *The New Technical Trader* (John Wiley & Sons, New York, 1994).

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FIGURE 69 Comparison of RSI and stochastic. (Panel a) Treasury bond prices for the June 1996 delivery. (Panel b) The 5day raw stochastic often reaches maximum and minimum Val. ues. (Panels c and d) Comparing the 5day RSI with the 20day stochastic. (Panels e and f) Comparing the 14day RSI with the 40day stochastic.





Source: Charts created with TradeStation® by Omega Research, Inc.

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$$n\text{-day StochRSI} = \frac{RSI_{\text{today}} - RSI_{n\text{-day low}}}{RSI_{n\text{-day high}} - RSI_{n\text{-day low}}}$$

Larry Williams' Oscillators

Larry Williams has been known for his development of trading methods based on oscillators since his publication of the AID Oscillator in 1972. Although they have changed over the 14 years spanning these systems, some similarities are apparent in Williams' three techniques that follow.

AID Oscillator

In 1972, Jim Waters and Larry Williams published a description of their A/D Oscillator in *Commodities* magazine. For their system, A/D means accumulation/distribution rather than the usual notation of advance/decline, a wellknown interpretive index for stocks. They used a unique form of relative strength, defining buying power (BP) and selling power (SP) as

BP = high - open SP = close - low

where the values used were today's open, high, low, and closing prices. The two values, BP and SP, show the additional buying strength (relative to the open) and selling strength (compared with the close) in an effort to measure the implied direction of the day's trading. The combined measurement, called the daily rawfigure (DRF) is calculated as

$$\text{DRF} = \frac{\text{BP} + \text{SP}}{2 \times (\text{high} - \text{low})}$$

The maximum value of 1 is reached when a market opens trading at the low and closes at the high: BP = high - low, SP = 0. When the opposite occurs and the market opens at the high and closes on the lows, the DRF will be 0. Each price series will develop its own patterns, which can be smoothed or traded in many ways similar to a momentum index. The Waters/Williams A/D Oscillator solves problems of volatility and physical limits. The daily raw figure completely adjusts to higher or lower trading ranges because the divisor itself is a multiple of the day's range; and because each day is treated independently, the cumulative values of the momentum index are not part of the results. This daytoday evaluation causes the DRF to vary radically and requires some smoothing technique or cycle interpretation to make it useable. As an example, look at the January 1977 soybean contract for the two months before delivery, November and December 1976. Table 61 shows the calculations for the DRF and for the smoothed DRF using an exponential moving average with a smoothing constant of 30% (selected arbitrarily). The daily raw figure is plotted as the solid line on a scale of .00 to 1.00 in Figure 610 and is extremely erratic in its movements. The dotted line is the smoothed DRF. Once plotted, two horizontal lines can be drawn to isolate the peaks and bottoms of the DRF; the top part becomes a zone representing an overbought condition and the bottom zone represents oversold. Bear in mind that these lines were drawn after the DRF was plotted and cannot be construed as predictive; however, in the article by Waters and Williams, their example of soybean oil had lines drawn in a similar place. Corresponding broken lines were drawn to indicate the overbought and oversold state for the smoothed DRF.

The rules for using the A/D Oscillator were not defined in the *Commodities* magazine presentation, but some simple rules could be:

Sell when the DRF (or smoothed DRF) penetrates into the overbought zone. Close out

all accumulated long positions, if any, and go short on the open of the next trading day.

Buy when the opposite condition occurs.

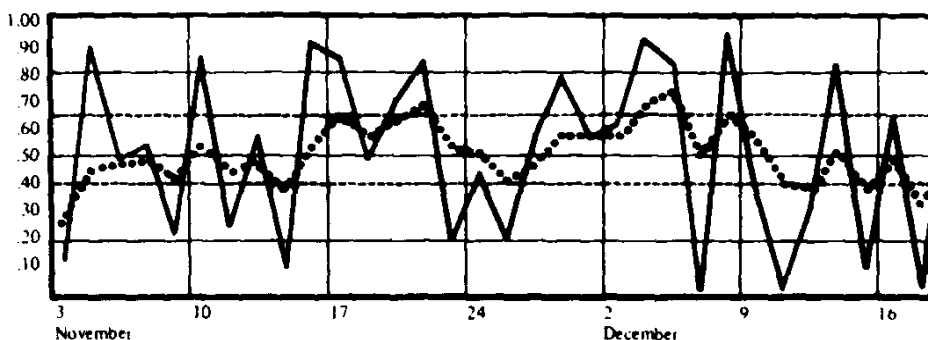
TABLE 61 AID Oscillator: January 1977 Soybeans

1976 Date	Open	High	Low	Close	DRF			30% Smoothed DRF
					DRF	DRF* Signal	Price	
11-01	682	686	674½	678½	.34			.34
11-03	679	683	655	658½	.13			.28
11-04	658	676	658	671½	.87	Sell	→ 674	.45
11-05	674	678	665	673½	.48			.46
11-08	673	685	671	674½	.54			.48
11-09	673	673	660	666	.23			.41
11-10	667	676½	665	675	.85	Sell	→ 660	.54
11-11	660	662½	645	651	.24			.45
11-12	652	658	650½	653	.57			.49
11-15	652	652	627	632½	.11	Buy	→ 639½	.37
11-16	639½	655	636½	654½	.90	Sell	→ 653	.53
11-17	653	671	649	668½	.85			.63
11-18	667	674½	658	666½	.48			.58
11-19	670	691	669½	678½	.70			.62
11-22	680	691	675½	690½	.84	Sell	→ 689	.68
11-23	689	696½	674½	675½	.20	Buy	→ 681	.54
11-24	681	686	678½	680	.43			.51
11-26	678	681½	670½	671½	.21	Buy	→ 670	.42
11-29	670	675	661½	672	.57			.46
11-30	668	677½	666	674½	.78			.56
12-01	676	681½	673	677	.56			.56
12-02	678	681½	675	679½	.61			.57
12-03	679	687	679	685½	.92	Sell	→ 690	.68
12-06	690	698½	689	696½	.84			.73
12-07	700	700	690	690½	.02	Buy	→ 691	.51
12-08	691	708	691	706	.94	Sell	→ 705	.64
12-09	705	712	702	703	.40			.57
12-10	704	704	696	696½	.03	Buy	→ 693	.41
12-13	693	695	690½	691½	.33			.38
12-14	696	701½	694	701	.83	Sell	→ 701	.52
12-15	701	702	684	687	.11	Buy	→ 688½	.39
12-16	688½	692	685	690½	.64			.47
12-17	690	690	676	677½	.05	Buy	→ 680	.34
12-20	680	684½	679½	683½	.82	Sell	→ 682	.49
12-21	682	688	679	687½	.80			.58
12-22	688	693	686½	689½	.60			.59
12-23	689	693	684½	692½	.71			.62
12-27	695	705	694	700½	.76			.66
12-28	701	706½	697½	705½	.76			.69
12-29	708	710	699	699½	.11	Buy	→ 703½	.52
12-30	703½	708	698	706½	.65			.56
Basic DRF Performance†					30% Smoothed DRF Performance†			
16 signals					7 signals			
4 compounded signals					3 compounded signals			
12 profits					5 profits			
Average profit					Average profit			
4 losses					2 losses			
Average loss					Average loss			
Net profit/loss					Net profit/loss			

* Signals taken the following day on open.

† No commissions have been deducted.

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FIGURE 610 A/D Oscillator



If the DRF (or smoothed DRF) enters an overbought or oversold zone more than once without the opposite zone being entered, one additional position is added at each reentry. Following these rules, the A/D Oscillator showed excellent success for both the raw and smoothed values. Accepting the afterthefact designation of zones, the results still show that the method is viable and that a smoothing technique can be applied to the DRF to vary the speed of trading.

Waters and Williarns used a simple 10day momentum for their example of the A/D Oscillator. The choice of interval can be determined by examining the tops and bottoms of a chart for the natural cycle of the prices.

In reviewing the A/D Oscillator, there are modifications to be considered. Conceptually, the value of the oscillator should be +1 when prices are rising rapidly. The most extreme example is a lockedlimit notrading day, representative of the strongest (or weakest) market. But for that case, the open, high, low, and closing prices are all the same and the DRF cannot be determined (since the divisor is zero). A more basic problem concerns gap openings. A much higher opening with a stronger close would also upset the resulting DRF For example the following trading occurs:

	Open	High	Low	Close
Monday	43.00	44.00	40.00	41.00
Tuesday	42.00	42.00	39.00	40.00
Wednesday	38.50	38.50	38.00	38.00
Thursday	42.00	42.00	39.00	40.00
Friday	40.00	43.00	40.00	42.00

Note that on Wednesday, the DRF indicates that the momentum has reversed, but in fact the price is failing rapidly and gives no indication of recovering; it may actually be gaining momentum. On Thursday the price soars up and closes in the midrange, but the DRF shows a new downward momentum. The problem seems to be related to lack of association with the prior closing price. The daily movement can take on different appearances

if the entire range was above or below the closing price. To form this link, replace the current high or low with the prior closing price if that price was outside the current trading range. The following example shows the results smoothed out and leaves the trend intact.

	<i>Open</i>	<i>High</i>	<i>Low</i>	<i>Close</i>
Monday	43.00	44.00	40.00	41.00
Tuesday	42.00	42.00	39.00	40.00
Wednesday	38.50	(40.00)	38.00	38.00
Thursday	42.00	42.00	(38.00)	40.00
Friday	40.00	43.00	40.00	42.00

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Another construction of an oscillator can be made using the highs and lows relative to the prior close:

$$O_t = \frac{H_t - C_{t-1}}{H_t - L_t}$$

The two days are linked together and the ratio of the high price is measured against the total range for the day. For the normal $C_{t-1} > H_t$ or $L_t > C_{t-1}$, C_{t-1} replaces either H_t or L_t to extend the ratio to be either 1 or 0 for these extreme cases. As with the A/D Oscillator, this method may also be smoothed.

Oscillators are not the only tools for measuring momentum in overbought or oversold conditions. Because it is very different from a moving average or a moving average, it is valuable either on its own or as a confirmation method.

A word of caution: Trading against the trend can be exciting but carries considerably greater risk than a trend-following system. The problem with a bought condition is that there is no way to hold losses to a minimum. Once a position is entered, the momentum or the oscillator value could move against the position.

%R Method

After the publication of Williams' *How I Made One Million Dollars Trading Commodities* (Conceptual Management, 1973), the %R oscillator became popular. It is a simple way of calculating where today's closing price fits into the daily range. Using the last 10 days, define

$$\%R = \frac{\text{buying power}}{\text{range}} = \frac{\text{high}_{10} - \text{close}_{\text{today}}}{\text{high}_{10} - \text{low}_{10}}$$

Williams' 10-day %R is actually a *10-day stochastic*, using the low price in the numerator; therefore, it is the complement (100% minus the stochastic) of the original stochastic calculation. With a chart that has the price at the bottom, a value below 95% will give a buy signal, and one above 95% will give a sell signal. Williams viewed this as a timing device to add positions with the fundamental trend. Trades were not to be entered if they contradicted the trend direction. Readers should refer to the earlier section in this chapter for more information.

The Ultimate Oscillator

In the *Ultimate Oscillator*, Williams seems to combine his oscillator with a great deal of Wilder's RSI.¹⁰ He adds the unique feature of three periods to offset the negative qualities of the short time period. The system is not too much. The Ultimate Oscillator works as follows:

1. Calculate today's *buying pressure* B_t by subtracting today's low from today's close. The true low is today's low or yesterday's close, whichever is lower.
2. Calculate today's *true range* R_t by taking either the difference between today's high and yesterday's close, or yesterday's close and today's low, whichever is greater.
3. Total the buying pressure B_t separately over the three periods designated as SB_7 , SB_{14} , and SB_{28} .
4. Total the true range R_t over the same three periods, designated as SR_7 , SR_{14} , and SR_{28} .

¹⁰ Larry Williams, "The Ultimate Oscillator," *Technical Analysis of Stocks & Bonds*, pp. 144-145.

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5. Divide the sum of the buying pressures by the corresponding true range, that is, SB_{71SR7} and scale by multiplying the 7day value by 4 and the 14day value by 2. All three calculations are now in the same scale.

Notice that the nearest seven values for the buying pressure and the true range are each used seven times; that is, they are multiplied by both the scaling factors of 4 and 2, and used once more in the 28day calculation. Williams has created a stepweighted momentum, assigning values of 7, 3, and 1 to the first 7 days, second 7 days; and last 14 days, respectively. The last 14 days account for only 10% of the total.

The rules for using this oscillator (see Figure 611) are:

1. A sell signal occurs when the oscillator moves above the 50% line (an upward divergence), and the oscillator peaks and then fails to break the peak on the next rally. Then, a sell order can be placed when the oscillator fails (on the right shoulder).
2. If holding a short position, close out the short when a long signal occurs, or when the 30% level is reached, or if the oscillator rises above 65% (the stoploss point) after being below 50%.
3. A buy signal occurs using the opposite techniques as the short signal (rule 1).
4. If a long position is held, close out longs when a short signal occurs, or when the 70% level is reached, or if the oscillator falls below 30% (after being above 50%).

Williams' Ultimate Oscillator has combined many important

features, including weighting time periods, setting objectives, stoploss points, and chart interpretation. There are two obvious weaknesses in this approach.

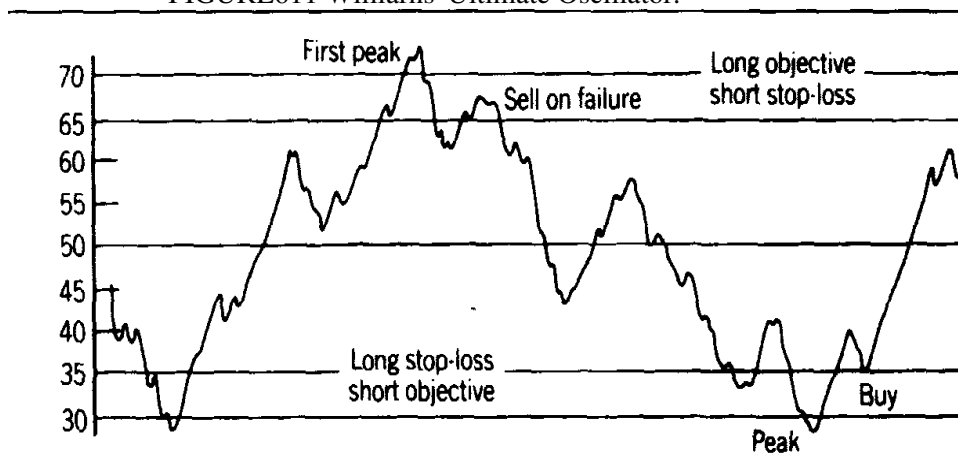
1. The chart rules add a great deal of subjectiveness to the method. Waiting for a failure of a second peak is another way of looking for a broadening top a slower rise followed by a rounding pattern. Waiting for a pattern may add reliability if interpreted properly, but it defeats the effect of the oscillator being a leading indicator
2. The stoploss rules apply only after the oscillator has crossed 50%. If it moves the wrong way immediately, there is no risk control.

DOUBLESMOOTHED MOMENTUM

The most recent contributions to the study of momentum have been made by William Blau." In addition to creating new momentum indicators, he has added substantial value to the old ones. Also refer to his work on double smoothing of momentum in Chapter 4 ("Trend Calculations").

" William Blau, *Momentum Direction and Divergence* (John Wiley & Sons, New York, 1995).

FIGURE611 William's Ultimate Oscillator.



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True Strength Index

Much of Blau's work combines double smoothing of momentum values (1period price differences), which has surprisingly little calculation lag. By using the momentum, he has based the calculations on values more sensitive than price, then slowed them down by smoothing. He refers to this as using momentum as a proxy for price. One of Blau's most popular indicators is the True Strength index (TSI), which combines these features:

$$\text{TSI}(\text{close}, r, s) = \frac{100 \times @\text{SmoothedAverage}(@\text{SmoothedAverage}(\text{close} - \text{close}[\text{close_close}[1], r], s))}{@ \text{SmoothedAverage}(@\text{SmoothedAverage}(@\text{Absv}(\text{close} - \text{close}[\text{close_close}[1], r], s), \text{smooth1}), \text{smooth2})}$$

where r is the period of the first momentum smooth
 s is the period of the second momentum smooth
 $\text{close} - \text{close}[1]$ is the 1-day momentum

Written in *TradeStation* format, where the two
smooth2, this formula is:

```
num = @smoothedaverage(@smoothedaverage(close - close[close_close[1], r], s))
denom = @smoothedaverage(@smoothedaverage(@absv(close - close[close_close[1], r], s), smooth1), smooth2);
TSI = 100*num / denom;
```

The numerator is the scaled value of the double smoothed momentum, and the denominator is the double smoothing of the absolute value of momentum. The 1-day momentum is first smoothed over the period r , and then over the period s . The relationship between the standard momentum (the difference in prices over r days) and the TSI can be seen in Figure 612. The momentum indicator, formed by using an MACD indicator with moving average values of 1 and 20, has the typical erratic pattern of prices, and a slight lead ahead of the peaks, formed by the pending crossing of the prices and moving average. The TSI is much smoother with peaks and valleys aligning with those of the prices. Buy and sell signals are created by smoothing the TSI signal line and buying when the TSI crosses above the signal line.

DoubleSmoothed Stochastics

Because of Blau's great interest in double smoothing, he defines the general form of a double smoothed stochastic as:

$DS(q,r,s) =$

$$\frac{100 \times @SmoothedAverage(@SmoothedAverage(close - @Lowest(low,q) - @Highest(high,q),r),s)}{@SmoothedAverage(@SmoothedAverage(@Highest(high,q) - @Lowest(low,q),r),s)}$$

where $close - @Lowest(low,q)$ is the numerator of the difference between the current price and the lowest price over the past q periods

$@Highest(high,q) - @Lowest(low,q)$ is the denominator, the greatest high-low range over the past q periods

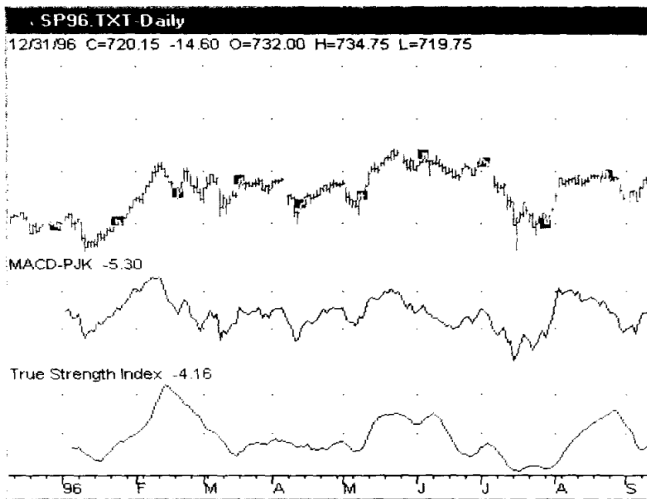
$@SmoothedAverage(. . . ,r),s)$ is an exponential smoothing factor, then over s periods, of the numerator

Forecast Oscillator

In Chapter 4 ("Trend Calculations"), the difference between the price and the trendline value was smoothed and added to the trend value to get what was originally considered a doublesmoothed trendline. Instead, the difference between the current price and the current trendline value is

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FIGURE612 Comparing the TS1 with a standard momentum over the same period.



Source: Chart created with TradeStation® by Omega Research, Inc.

responding forecast (trendline) price can be calculated as a momentum indicator $\%F$ ¹². This oscillator is not bounded as a percentage, there will be more consistency over very long

$$\%F = 100 \times \frac{\text{close}_{\text{today}} - \text{close}_{\text{previous}}}{\text{close}_{\text{today}}}$$

For practical purposes, a 3-period smoothing of $\%F$ is used. If $\%F = 0$, then the trendline and prices are moving parallel to each other; the market is accelerating away from the trendline; and when $\%F$ is negative, the two series are converging. Traders interested in this section on acceleration.

An Oscillator to Distinguish between Trending and Sideways

The lack of predictability of trending markets is the greatest problem found under the topics "Directional Movement" and "Control" in this book discusses that issue. Based on the idea that the trend is stronger when price is farther from fair value, and the trend is weaker when price is near value, an oscillator can be created to measure the trend component based on this concept,

$$\text{Strength Oscillator} = \frac{(\text{avg}(\text{close}_{\text{today}} - \text{close}_{\text{previous}}, n))}{(\text{avg}(\text{high}_{\text{today}} - \text{low}_{\text{today}}, n))}$$

As the trend increases, the average change in closing price increases relative to the high-low range for the day. In an unusual period, when the trend is very strong, it is possible for the closes to become larger than the daily range.

¹² Tushar Chande and Stanley Kroll, *The New Technical Trader* (John Wiley & Sons, 1999).

change over the period n should be close to zero. This oscillator can be smoothed by taking the change in price over 2 or 3 days, rather than the most recent day, as well as the highlow range over the same number of days.

ADDING VOLUME TO MOMENTUM

A momentum indicator can also incorporate volume by multiplying the price change over n periods by the total volume over that same period. The use of a cumulative period will help to stabilize the volume, which is often erratic. Although the sum of the volume over the period can be used, the average will appear more familiar and can be plotted against a volume chart. In standard and programming notation, that gives the momentum times the volume MV as:

$$MV = (\text{price}_t - \text{price}_{t-n}) \times \frac{\sum_{i=t-n}^t \text{volume}_i}{n}$$

$$MV = (\text{close} - \text{close}[n]) * @Average(\text{volume}, n)$$

Alternately, the price change of n periods could have been divided by n to give a perunit value. This section will include those techniques that combine price change and volume: for methods that do not use price, see Chapter 10 ("Volume, Open Interest, and Breadth").

Scaling by a Percentage or Volatility

The same conversions can be applied to momentum with and without volume. Using a percentage, rather than price, will add some robustness over long test periods. Because volatility often increases when prices rise faster than the percentage would show, momentum can be scaled according to a shorter measure of true range. If the true range is averaged over 20 to 65 days, approximately one month to one quarter, then the 1day change in price will become a relative momentum value. By using a much longer period for averaging the true range, you can create a stable profile of the volatility changes in the underlying market.

(Percentage momentum with volume)

$$\%MV = (close - close[n]) / close[n] * @Average(volume, n)$$

(Momentum with volume scaled by true range)

$$TRMV = (close - close[n]) / @Average(@TrueRange, p)$$

where @TrueRange is always calculated for the most recent period and @Average(@TrueRange, p) is the average of the 14 periods.

VolumeWeighted RSI

In the same way that the RSI adds the positive days and divides by the sum of the negative days, it is possible to weight each day by its volume to add another factor, called money flow," to the calculation. A positive or upward day is when the average of today's high, low, and close (high + low + close/3) is greater than the previous average. Each average is then multiplied by the volume, giving the daily money flow, and a ratio of the past 14 days is used to create a money ratio and finally a money flow index, both steps similar to Wilder's RSI.

" Gene Quong and Avrum Soudack, "VolumeWeighted RSI: Money Flow," Technical Analysis of Stocks & Commodities (March 1989).

$$\text{Money Flow} = \text{volume} \times \frac{\text{high} + \text{low} + \text{close}}{3}$$

$$\text{Money Ratio} = \frac{14\text{-day positive money flow}}{14\text{-day negative money flow}}$$

$$\text{Money Flow Index} = 100 - \frac{100}{1 + \text{Money Ratio}}$$

Herrick Payoff Index

Using the change in the underlying value of the change in price, the Herrick Payoff Index (HPI)¹ generate an indicator that, as the basic momentum down to a manageable value and smoothed using The daily value is:

$$\text{HP} = cf \times V_t \times (M_t - M_{t-1}) \times \left[1 + \left(\frac{M_t - M_{t-1}}{|M_t - M_{t-1}|} \right) \right]$$

and the index is an exponential smoothing of the

$$\text{HPI}_{\text{today}} = \text{HPI}_{\text{previous}} + s \times (\text{HPI}_{\text{today}} - \text{HPI}_{\text{previous}})$$

where t is today

$t - 1$ is the previous day

cf is the conversion factor (value of a basis

V_t is today's volume

$(M_t - M_{t-1})$ is the difference in the mean p

$| |$ (vertical bars) are for absolute value

$|OI_t - OI_{t-1}|$ is the absolute value of the c

$\min(OI_t, OI_{t-1})$ is the smaller of today and

s is a smoothing constant (default 10)

The expression that divides the change in mean change is used to create a +1 or -1 value. This coding programming code as

```
HP = @BigPointValue * volume * ((high-low)/2
    (1 - (((high-low)/2 - (high[1]-low[1])
    (high[1]-low[1])/2))* 2 * (@Abs(opint
```

```
HPI = @SmoothedAverage(HP,19)
```

Most analysts who use the Herd Payoff Index divide the HPI by 100,000 to reduce the value to a more useable level. The final series, when

seen along with prices, may appear volatile and require an interpretation using trendlines. This is due to the fluctuations in volume and open interest, which are smoothed over 20 days, rather than longer. The HPI may be helpful, despite the volatility, because it is a combination of factors not included in most other indices. It will have patterns that appear to lead price change to compensate for market noise.

14 From the original CompuTrac manual, which is now the Bridge Telerate division.

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Comments on the Use of Volume

Volume is an important piece of information, but it can be difficult to interpret. It fluctuates in a much larger range than price, and may be one-third higher or lower from day to day. Although it indicates market interest and potential volatility, there are many days for which a high or low volume does not have a consistent reaction.

In general, adding volume to an indicator will result in a more volatile, erratic series. Therefore, the first steps in using volume would be

1. Create a longterm, smoothed volume series.
2. Compare current volume for extremes to identify only those exceptional days that should be followed by high volatility.
3. Low volume should not be determined by a single day, but by either a few unusually low days together or by a volume decay over a modest time period.

VELOCITY AND ACCELERATION

A method conceptually similar to momentum is derived from the concepts in physics of velocity and acceleration, both elements in the science of motion. Velocity, as defined in mechanics, is the rate of change of position with respect to time (also called speed). There are two types of velocity, average and instantaneous. The average velocity is simply calculated as the mean velocity over a fixed distance and for a fixed time interval. In working with commodity prices, the time interval used will be days and the distance is measured in points; so that if silver moved 40 points in 6 days, its average velocity is

$$\bar{v} = \frac{40}{6} = 6 \frac{2}{3} \text{ points per day}$$

In general, the average velocity is expressed

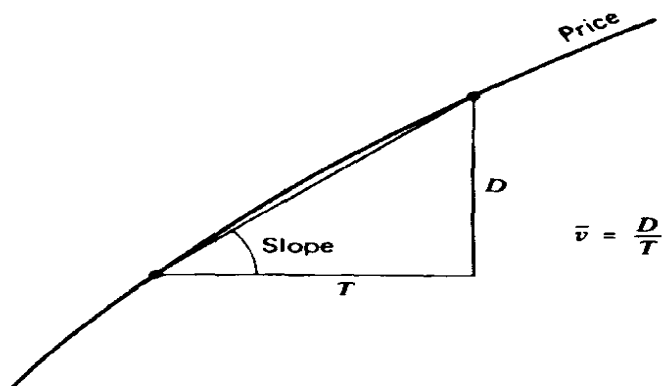
$$\bar{v} = \frac{D}{T}$$

where D is the total elapsed distance over the time span. In the case of momentum, D (the change in price) can be divided by the time span to get exactly the same results for average velocity.

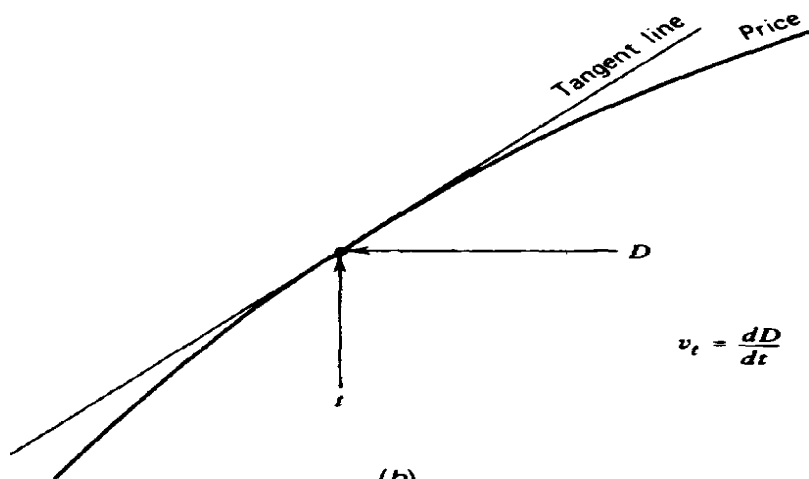
The instantaneous velocity v , which is the velocity at a single point, will be different. To determine the instantaneous velocity, *differentiation* is used. It effectively looks at smaller and smaller distances on the price curve until it reaches a single point. The results of the process of differentiation are expressed

$$v_t = \lim_{\Delta t \rightarrow 0} \frac{\Delta D}{\Delta t} = \frac{dD}{dt}$$

This shows that the velocity taken at any point is the limit of taking progressively smaller distances without reaching zero. This is covered in any advanced mathematics book. Only the results are presented here. If v represents the speed or momentum of the price at time t_1 , and at t_2 , . . . , then the velocity is increasing; if v gets smaller, then the velocity is decreasing. If the velocity also denotes direction, it can be both positive and negative, similar to a momentum indicator. Systems applied to velocity. Of course, some of the basic equations used for a velocity trading plan, because the value



(a)



(b)

and weighted moving averages, and exponential smoothing all have constant velocities. Only those equations with secondorder smoothing will work.

When the process of differentiation is reapplied to the equation for velocity, it results in the rate of change of the speed with respect to time, or acceleration. This type of acceleration tells whether the velocity is increasing or decreasing at any point in time. The acceleration, also called the second derivative, adds another dimension to momentum and may improve the timing of trades.

Let's assume that the velocity and acceleration have the following are the possible combinations that can occur:

Vel	Acc	Price Movement
+	+	Price is moving up at an increasing rate
+	0	Price is moving up at a constant rate
+	-	Price is moving up at a decreasing rate
0	0	Price is static
-	+	Price is moving down at a decreasing rate
-	0	Price is moving down at a constant rate
-	-	Price is moving down at an increasing rate

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TABLE 62 Equations for Velocity and Acceleration

	Basic Equation	Velocity
Straight line	$y_t = a + bx_t$	$v_t = b$
Curvilinear	$y_t = a + bx_t + cx_t^2$	$v_t = b + 2cx_t$
Logarithmic (base a)	$y_t = \log_a x_t$	$v_t = (\log_a e)/x_t$
Logarithmic (natural log)	$y_t = \ln x_t$	$v_t = 1/x_t$
Exponential	$y_t = e^{ax_t}$	$v_t = ae^{ax_t}$
Moving average	$y_t = \frac{x_t + x_{t-1} + \dots + x_{t-n+1}}{n}$	$v_t = 1$
Weighted moving average	$y_t = \frac{a_1x_t + a_2x_{t-1} + \dots + a_nx_{t-n+1}}{n}$	$v_t = \frac{a_1 + a_2 + \dots + a_n}{n}$
Exponential smoothing	$y_t = y_{t-1} + c(x_t - y_{t-1})$	$v_t = c$

* Because velocity and acceleration are time derivatives, all equations implicitly include the factor Δt .

Using the acceleration feature, a change of velocity (or momentum) can be detected, or the strength of a current price move can be confirmed. Quick Calculation of Velocity and Acceleration

A less precise but very convenient way of determining velocity and acceleration is the calculation of first and second differences. The purpose of these values is to find more sensitive indicators of price change, and most traders will find this quick calculation satisfactory. The results can be

used in exactly the same way as the formal mathematical results. Consider the following examples:

1. A price series 10, 20, 30, 40.... is moving higher by a constant value each day. The first differences are 10, 10, 10, . . . , showing a consistent velocity of 10. The second differences, formed by subtracting sequential values in the first difference series, are 0, 0, 0, . . . , showing that there is no change in speed; therefore, the acceleration is 0.
2. Another price series is shown with its first and second differences as

t	1	2	3	4	5	6
S	10	15	20	30	45	50
V		+5	+5	+10	+15	+5
A			0	+5	+5	-10

where S is the price series

V is the velocity (first differences)

A is the acceleration (second differences)

The original series S has two turns in trend clearly shown by the velocity and acceleration. The velocity V continues to be positive through the sixth value as the underlying price moves from 10 to 50. Whenever prices change direction, the velocity changes sign. The basic upward trend can be associated with a positive velocity and a downward trend with a negative one.

The acceleration, or second difference, shows the change in speed. At the sixth item, the acceleration becomes negative, even though the velocity was positive,

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because prices moved higher at a slower rate. They had been gaining by 5, 10, and 15 points each day, but on day 6, the gain was only 5 points. This reversal in acceleration was a leading indicator of a trend change. A similar situation occurred on day 8, when the acceleration slowed and reversed on day 10, one day ahead of the actual price reversal.

The relationship between velocity and acceleration using first and second differences can be interpreted using the same logic as previously discussed. Velocity and acceleration are increasingly more sensitive directional indicators; the slightest variation in price movement will cause the acceleration to reverse. It is an indicator of great value when it is used selectively.

OTHER RATE OF CHANGE INDICATORS

Projected Crossovers

If moving averages can successfully be used to identify the trend direction, it follows that a projection of the moving average will be valuable in anticipating when the trends will change. If a moving average

trading strategy used a single trend, the price at which the standard Nday moving average line would cross the price CP1 is

$$CP1 = \frac{\text{sum of last } N - 1 \text{ prices}}{N - 1} = \frac{\left(\sum_{t=N+2}^t P_t \right)}{(N - 1)}$$

To calculate the price at which two moving average

$$CP2 = \frac{N \times (\text{sum of last } N - 1 \text{ prices}) - M \times (\text{sum of last } M - 1 \text{ prices})}{(M - N)}$$

where N and M are the lengths of the two moving average

The projected crossover price is most useful when it occurs within a few days, that is, when the two moving averages become close in value. Acting on the expected price crossover is a common trading strategy in order execution. A plot of this, however, may be used as a *relative strength* measurement. The difference between the two moving average lines constitutes the relative strength.

The change in the projected crossover is considered a trend indicator. He creates a *Market Direction Indicator* (MDI) with

$$MDI = \frac{100 \times (\text{crossover price}_{\text{previous}} - \text{crossover price}_{\text{current}})}{\text{average of past 2 day's prices}}$$

The point at which the MDI crosses the zero line is a buy signal. The point at which it crosses moving lower is a sell signal.

Combining a Trend and Oscillator

Directional Parabolic System

The *Directional Parabolic System*¹⁶ is a combination of the Parabolic Trending System, Directional Movement and the Parabolic Time Series. It is covered fully in Chapter 23. It gained popularity

¹⁵ Donald R. Lambert, "The Market Directional Indicator," *Technical Analysis of Stocks & Bonds* (January/December 1983). This article also contains a BASIC computer program.

¹⁶ J. Welles Wilder, Jr., *Chart Trading Workshop 1980* (Trend Research, Inc., 1980).

Parabolic Time/Price System is covered in Chapter 17 ('Adaptive Techniques'). Although a full reading of both techniques are necessary, the essence of the combined systems can be understood with the following definitions:

+DI 14 The 14day upward Directional Index

DI 14 The 14day downward Directional Index

ADX The average Directional Movement Index

DPS The Directional Parabolic stop

Although shown as D114, the downward Directional Index is a positive number based on the sum of those days that closed lower. The ADX is a ratio of those days that closed higher with those that closed lower over the past 14 days. The ADX is an oscillator based on the scaled ratio of +DI/DI. The two systems combine according to the following rules:

1. If the ADX is up (the +DM14 is greater than the DM14), take only long Parabolic System trades; if the ADX is down, take only short trades.

2. If the two systems conflict, no trade is entered. A trade may be entered at the time they agree.

3 If a position is held, the Parabolic stop is used. (The stop is now called the DPS instead of the SAR, because it no longer requires a reversal of position.)

4. If no position is held, the Directional Movement equilibrium point is used (the high or low of the day on which the +DM 14 crosses the DM 14).

Directional Parabolic Revision

In 1980, the entry rules were revised to include an added use of the ADX when it is greater than the +DI 14 or the DI 14. Because the ADX serves as an oscillator and indicates turning points in the trend, when the ADX exceeds the magnitude of the current +DI14 or DI14 and reverses, the current position should be closed out. If the ADX remains above both the +DI 14 and DI 14, the market is extremely strong and liquidation should stop. The ADX is intended to be a leading indicator for liquidation only. Reversal of the current position only occurs when the Parabolic stop has been penetrated, and the new trade agrees with the direction of the Parabolic System.

The addition of an oscillator to a trendfollowing system allows trades to be closed out at more favorable positions than the usual trend exits. If the new direction carries through and the position is reversed, the added feature has worked perfectly; however, if prices turn back in the original direction, a reentry may not be possible. The revised rules are unclear concerning reentry into a position if prices fail to penetrate the DPS and signal a reversal. A reentry might occur if the ADX falls below both the +DI14 and DI14, indicating that prices are no longer extreme, then turns back in the trend direction. Once reestablished, the DPS can be used and additional exits using the revised rules would apply.

Cambridge Hook

A combined indicator that has received some promotion is the Cambridge Hook, used by one commodity trading advisor. (17) It is intended to

identify an early reversal of the current trend by combining the following indicators (applied to an existing uptrend):

1. An outside reversal day (a higher high followed by a lower close)
2. Wilder's RSI must exceed 60% (moderately overbought)
3. Volume and open interest must be increasing

17 Elias Crim, 'Am You Watching the 'Right' Signals?' Futures (June 1985).

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The result is a high likelihood of a downward trend reversal (the opposite applies to upward trend reversals). Protective stops are placed above the high of the hook on the day that signaled a downward reversal.

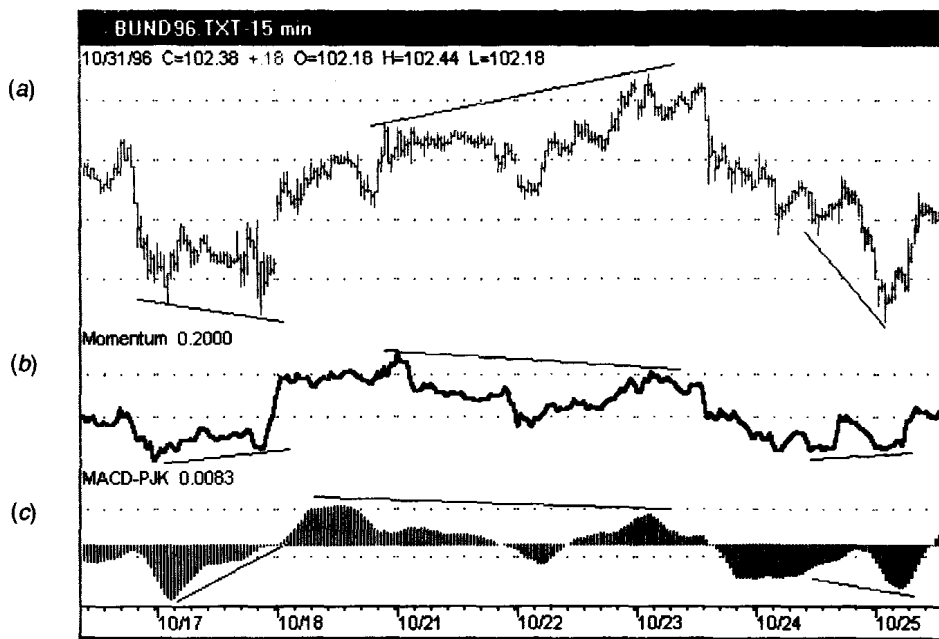
MOMENTUM DIVERGENCE

Divergence is a concept familiar to most traders. It is frequently seen in the Dow Jones industrials versus the Dow Jones Utilities, when the Utilities indicate a downturn in the economy in advance of any sign in the DEFIANT price pattern. The prices of the S&P 500 are also watched closely in conjunction with the 30year U.S. Treasury bonds. When bond prices fall, the S&P can't be far behind. The underlying relationship of two markets that make divergence important can also be represented technically by the slope of trendlines and the alignment of relative peak prices.

An unsmoothed momentum chart has as many irregular ups and downs as a normal price chart and is often subjected to the same analysis. Trendlines are drawn across the tops and bottoms of chart sections and can be interpreted in a manner similar to their price counterparts (as shown in Figure 614), with two significant differences:

1. The trend of a momentum chart shows the speed of the trend, but allows us to see the rate of change of price. For example, an unchanged momentum value of +. 10 is actually a steady increase of +. 10 in the relative price level; that is, a price sequence of 102.20, 102.30, 102.40.... would show a momentum of +. 10 and would appear as a horizontal line on a chart. In this example, the change (momentum) is. 10, but the rate of change (acceleration or deceleration) is 0. When the momentum increases, the rate of change is positive; a downtrend in the momentum means that the rate of change is negative. A steady uptrend in the momentum means that price

FIGURE 614 Divergence of price and momentum. The trendline drawn across the price moves (panel a) and the corresponding momentum (panel b) and MACD (panel c) indicators shows that the directions diverge.



Source: Chart created with TradeStation[®] by Omega Research, Inc.

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movement is accelerating at a steady rate (for example, a gain of .10 the first day, .20 the second day, .30 the third, and so on), moving faster and faster, a situation that is not likely to continue; therefore, these periods are relatively shortlived.

2. The divergence between the price trend and momentum trend creates a very strong indicator of impending change in the direction of the price trend. A bearish divergence occurs when prices continue higher, while momentum moves lower. This is typically seen by drawing a trendline above the rising tops of the prices, as shown in panel a of Figure 614, and above the falling tops of the momentum indicator, seen in panels b and c of Figure 614. The reason for this pattern is that prices are actually rising at a slower rate, causing the new price peaks to be farther apart.

Figure 614 gives three examples of divergence using two different momentum indicators, the difference between prices and a single moving average (Figure 614, panel b), and an MACD, the difference between two moving averages (Figure 614, panel c). The classic example is in the center of the chart, where prices make new highs near the close of 10/22, while both of the momentum indicators show lower peaks. In classic divergence the trendlines drawn on the price chart must be in absolute contrast to the direction of those drawn on the momentum chart. That is, one must be going up and the other down. The failure of momentum to make a corresponding high peak indicates a downturn in prices.

On the left side of Figure 614 is a bullish divergence, in which prices

make new lows while the momentum indicators rise. In this case, the MACD is much stronger than the standard momentum. On the far right, a bullish divergence appears in the center panel but not in the MACD indicator. Standard momentum indicates a modest rise in value while the MACD declines quickly. Not all changes in price direction are identified by the divergence of price and momentum, but it remains a valuable tool.

We can distinguish between a stronger and weaker divergence by measuring the difference in the relative angles of the two trendlines, but mostly by the momentum trendline. In a bearish divergence situation, the price trend is normally increasing at a slow rate, and becoming slower. When the momentum drops quickly there is a strong divergence and the price rise is quickly ending.

Slope Divergence

To change an interpretive analysis to one that can be computerized, there are two techniques, one using slopes and the other based on the analysis of peaks. A comparison between the rate at which prices and a momentum indicator are rising or falling will give enough information to automatically identify a divergence. Using a linear regression feature in either a spreadsheet (@Slope) or a strategy testing program (@LinearRegression), the slope of any time interval can be found for both momentum and price over the same period. Because momentum is a detrended series, the period compared should not be too long; otherwise, the slope of the trendline will be zero, a horizontal line. Instead of the trendlines that appear above and below prices and momentum in Figure 614, the regression lines will pass through the center of the price movement.

Divergence can be any combination of conflicting directions between the slope of price and the slope of momentum, including prices rising faster than momentum, momentum rising faster than prices, or the opposite. However, classic analysis has focused on momentum as a leading indicator of a change in the price trend, which limits the combinations to:

1. Prices rising and momentum falling (a bearish divergence)
2. Prices falling and momentum rising (a bullish divergence)

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The strength of a bearish divergence, which can be used to select which situations are best for trading, can be determined by the momentum slope provided prices are rising, or the net of the rising slope of prices and the falling slope of momentum. In the second case, the difference between the slopes must be converted to a common denominator, because the angle of price movement can cover a far wider range than the angle of momentum movement.

Divergence Using Peak Comparisons

The identification of divergence for a shortterm trader is very different from the slope technique that applies to the major moves seen in the Dow Jones Industrials and Utilities. In this application, the peaks (or valleys) of any momentum indicator are compared against the corresponding peaks (or valleys) of the price series (upon which the momentum was calculated). If the momentum peaks are declining and the

price peaks are rising there is a divergence. In Figure 614 the ups and downs between the peaks are ignored, and only the points at which the prices form swing highs and lows are compared with corresponding momentum values.

it is easier to find divergence by looking at a chart on a quote screen than to program it into a computer. Translating what you see into a systematic analysis of divergence signals is very difficult. There are a number of steps necessary for signaling a bearish divergence:

1. Identify each momentum peak and record its value, MP_i . The standard approach to finding a momentum peak is to locate each momentum value that is higher than the previous n values and higher than the next n values. In addition, the first momentum peak of a sequence must be above a threshold level, for example 80, to assure that an overbought situation has occurred. It seems reasonable that all momentum peak values should be greater than some level, for example 50, to avoid having already reached the correction objective before a position can be entered (see Step 4).
2. Identify the price peaks corresponding to each momentum peak, PP_i . This is done in the same way as Step 1 or the corresponding value of the price can be used, assuming that it produced a peak.
3. Compare the last momentum peak, MP_i , with the previous momentum peak, MP_{i-1} , and their corresponding prices, PP_i and PP_{i-1} . A bearish divergence exists if $PP_i > PP_{i-1}$, and $MP_i < MP_{i-1}$. A stronger divergence exists if MP_i is larger.
4. Enter a short position when the divergence is identified, provided prices have not already reached the correction level or anticipated profit. This fourth step points out a problem in this method of finding a divergence. The need to wait a number of days after a momentum high will cause many of the signals to be too late. Although the price may have been higher at the time of the second peak, the lag needed to recognize the next declining momentum peak gives the price a chance to correct before a signal can be generated.
5. Exit the short position when the current momentum moves above the last momentum peak. This new momentum high indicates that the divergence, used as the entry criteria, has disappeared and there is no basis for this trade. The exact price at which this occurs cannot be calculated in advance.
6. Exit the short position when the market has corrected or an objective has been reached. Once the momentum has declined to the midpoint level of 50 for the RSI and stochastic, it should be considered neutral and cannot be expected to continue on to negative values. A price objective can be set using volatility or support levels.

Single, Double, and Triple Divergences

In fewer cases, double and triple divergences will occur. A double divergence is one in which three momentum peaks are declining and price is rising in each case. Most often, the second momentum peak is only slightly lower than the first, and the last peak drops off indicating that price

is soon to follow. Multiple divergences are expected to be more reliable than single, and represent a prolonged period in which prices are rising at a slower and slower rate.

Alternating Divergence Peaks

A common pattern is that there is a lower momentum peak between two declining peaks. For example, the first momentum peak is at 90, the next at 60, and the last at 5. When studying the chart manually, most analysts will ignore the lower peak in the middle and consider the 9075 divergence. This combination can be automated by looking at the most recent momentum peak, i , and the one back 2, $i - 2$, along with their corresponding prices.

Converting a Divergence into a Trend Trade

Divergence trades represent a clear chart pattern of slowing price direction. At the same time they are countertrend trades and have a higher degree of risk. Before the October 1987 stock plunge, there were numerous divergence signals in the S&P, both longterm and shortterm, and many traders posted losses trying to sell what might have been the top of the market. Most gave up before the decline. If, in fact, the greatest opportunities come when the divergence is strong, that is, the decline in the momentum peaks is large, then the best results will come from entering a short position, then holding that short when a long trend turns to a short one. By entering the trend trade early (and exiting the old long position), a divergence can become a large profit rather than a small one.

MOMENTUM SMOOTHING

When Blau's work on double smoothing was discussed in the section "True Strength Index," it was still being compared with other momentum indicators. The most important part of his work, however, is in using price change as a substitute, or proxy, for prices themselves, then smoothing them to define the trend. A longterm moving average, applied to prices, produces a lag of onehalf the period of the moving average, that is, a 200day moving average has a lag of 100 days.

The same moving average technique applied to price change, or momentum, gives very different results because price changes, also called first differences, remove the underlying trend and make price movement more sensitive. Applying a longterm moving average to momentum is an excellent substitute for price, yet it oscillates around the average value of zero in a manner similar to other momentum indicators.

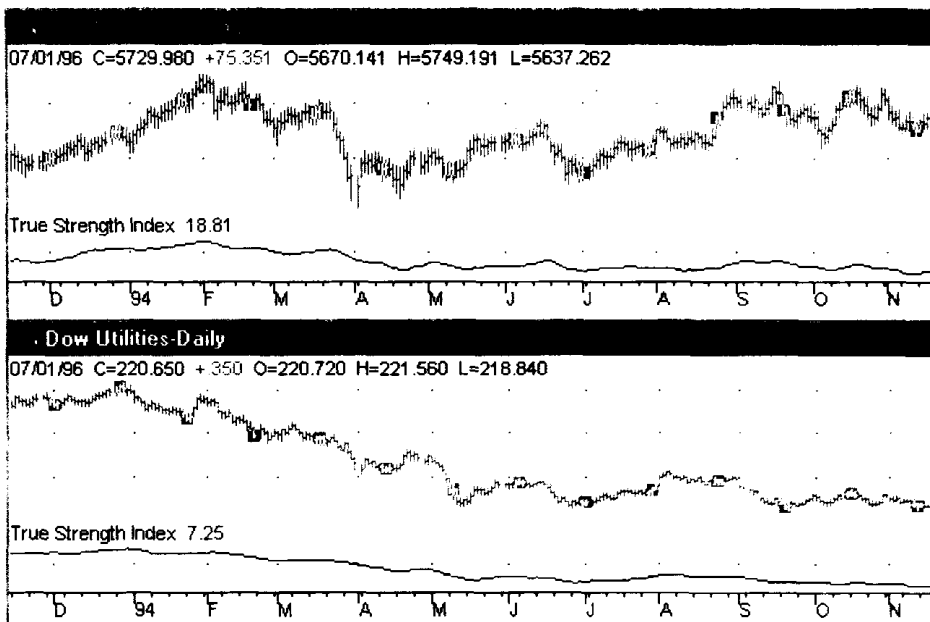
Double Smoothing of Momentum

Double smoothing of momentum is an extension of normal momentum smoothing, and results in a value that has less noise than the original momentum series, and retains its lowlag characteristics, provided that one of the smoothing periods is very large. Double smoothing of momentum can be a smooth substitute for price, without a significant lag (see Figure 612). The shape of Blau's True Strength Index (TSI), first smoothed over a 300day period, then smoothed again over a 5day period, closely approximates the result of a 5day exponential smoothing (EMA). When applied using the same smoothing periods, this can be very useful for identifying divergence between two markets. In Figure 615 the trend of the

TSI line is still up at the end of February 1994, making a new high in both

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FIGURE 615 Doublesmoothed momentum applied to the Dow Jones Average and Dow Jones Utilities, showing divergence.



Source: Chart created with TradeStations by Omega Research, Inc.

the prices and indicator, while the utilities are steadily heading lower. In December 1994 there is a turn up in the TSI for the utilities that will lead the DJIA throughout 1995.

TSI (close, 300,5) =

$$100 \times \frac{(@SmoothedAverage(@SmoothedAverage(close, 5, 1)))}{(@SmoothedAverage(@SmoothedAverage(@abs(close, 5, 1)), 5, 1))}$$

When the 5day momentum is replaced by a 1day momentum, or the daily price changes, the second smoothing can be any length, and the result is a very effective substitute for a moving average of price with the significant added advantages of a detrended series, lower noise, and less lag. When plotted, the series fluctuates around the value zero unless there has been a strong trend during the full period, as in the stock index.

SOME FINAL COMMENTS ON MOMENTUM

Momentum and oscillators are not the only tools for determining overbought and oversold conditions. Because they can be very different from either a charting technique or moving averages, they have taken their place as timing indicators within other more structured systems. When the

time interval for calculation is small, these indicators can be highly unstable, jumping from frequent overbought signals to just as frequent oversold ones. Both faster and slower speeds have the problem of risk control. The method implies that a position be entered contrary to the direction of price movement. Although chart interpretations attempt to remedy this, unusually large losses may result.

It is not likely that an indicator can be found that will identify only the trades that Will be profitable. It is far more likely that an indicator will add more patterns to the already difficult combinations that are seen in price; therefore, it is not clear whether an indicator will simplify trading or make it more complex. if you need to interpret the indicator because each situation creates new decisions, then you've got the wrong one.

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indicators can be designed to reach extremes when a specific situation occurs. During other times it tells us nothing. One practical use of any oscillator is to show when a market is relatively overbought or oversold. if you are using a trending approach, and each trade is held about 20 days, an oscillator can be tuned to provide entry timing. For example, if you are willing to wait up to 2 days to enter a long position based on the daily close, then construct a 10period oscillator of 5, 10, or 15minute data. Test the oscillator to see if it generates at least one, but preferably two, oversold signals during each 2day period. If so, use it to time your entry and you are likely to be buying dips rather than rallies.